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ABSTRACT

More than 100 college students enrolled in a reading and study skills course participated in a study designed to show the effects of retrieval speed on adult reading comprehension. A microcomputer version of the Posner task was used to measure memory retrieval speed, and reading and listening comprehension were measured from McCall-Crabbs paragraphs. Stepwise multiple regression analysis demonstrated that a composite of the reaction time to Perceptually Identical and Name Identical displays accounted for approximately 25% of the residual variance after listening comprehension was used to predict reading comprehension. Automaticity, decoding speed, and general speed measures did not seem to provide alternative explanations of this phenomenon, so retrieval speed was supported as a factor in adult reading comprehension. (Author/FL)

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RETRIEVAL SPEED AS A DETERMINANT OF ADULT READING COMPREHENSION

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CS 007322

Abstract

In order to show the effects of retrieval speed on adult reading comprehension, a microcomputer version of the Posner task was used to measure memory retrieval speed. Reading and listening comprehension were measured from McCall-Crabbs paragraphs. The tasks were presented to 121 undergraduate students in a college-level reading and study skills course. Stepwise multiple regression analysis demonstrated that a composite of the reaction time to Perceptually Identical and Name Identical displays accounted for 25.4% of the residual variance after listening comprehension was used to predict reading comprehension. Automaticity, decoding speed, and general speed measures do not seem to provide alternative explanations of this phenomenon, so retrieval speed is supported as a factor in adult reading comprehension.

The rapid retrieval of words from a person's long-term memory (LTM) has long seemed to be an important reason why some poor readers with adequate or good intelligence read as poorly as they do (Chall, 1967; Satz & Morris, 1981). In particular, Wolf (1982) has made a persuasive case that retrival, as measured by level of picture naming (Boston Naming Test, Kaplan, Goodglass, & Weintraub, 1978), is an important determinant of the reading level of school-age children. Indeed the same point seems to be made by studies which show that "automaticity" (LaBerge & Samuels, 1974), speed to name a display of common objects (Denckla & Rudel, 1968), and slow decoding (Perfetti & Hogaboam, 1975) separate good readers and poor readers, non-dyslexics and dyslexics, and good comprehenders and poor comprehenders, respectively.

At the present time, there is no picture naming test which measures the wide range of adult performance necessary to separate poor from good readers, or includes symbolic and conceptual vocabulary which is not easily pictured. A test, such as Rapid Automatized Naming (Denckla & Rudel, 1968) shows only small differences with older children and adults and the ability of naming speed for individual letters to predict reading has been questioned (Stanovich, 1981). Thus, an alternative means of testing important aspects of retrieval of word names and meanings and their influence on adult reading comprehension is needed.

Jackson (1980) has recently used a variant of the Posner task (Posner, Boies, Eichelman, & Taylor, 1969) to account for differences

between listening and reading comprehension. A wide variety of different forms of the task occur in two papers (Jackson, 1980; Jackson & McClelland, 1979), of which, the basic Posner task, using capital and small letters, seems to be about as useful as any of its variants for predicting the differences between listening and reading comprehesion. Thus, the retrieval measue itself, not its specific content, seems to be the important measure. The task measures reaction time to make a "same" judgment when two identical capital letters (Perceptual Identity--PI) or a capital letter and its corresponding miniscule form (Name Identity--NI) are presented. To the extent that NI Reaction Time (RT) is longer that PI RT, the extra time is presumed to access and/or compare the names of the two forms of the letters.

Reading level cannot be considered poor without a comparison between a person's reading level and an expected level of reading. Reading Expectancy scores (Harris & Sipay, 1980) form one important basis for this. Comparisons of listening and reading comprehension also do this, using the level of listening comprehension as the task which measures the expected level of comprehension (e.g., Smiley, Oakley, Worthen, Campione, & Brown, 1977; Kirby & Das, 1977) because it requires comprehension without the additional visual and cognitive demands of translating words from print (Marsolin, Griebel, & Wolford, 1982). Listening comprehension is usually seen as a measure of ability to understand spoken language and somewhat separate from reading comprehension and reading tasks required by Jobs (Sticht, 1980).

In the present study, we investigate reading comprehension, listening comprehension, and the use of the Posner task to measure retrieval speed. Reading and listening comprehension were defined from tasks taken from a common source of comprehension materials (McCall & Crabbs, 1979) and the Posner task was presented on a TRS-80 microcomputer.

Method

Subjects

Data were collected from 121 students from classes in the Montclair State College Reading Improvement Program (CRIP) and Teacher Education Reading Classes. CRIP is an elective course that includes a wide variety of students who seek improved reading and/or study skills. The verbal and mathematics SAT scores, GPA, and the high school rank of each subject were obtained when possible from college files after the completion of the study.

Apparatus

The microcomputer used for the presentation of the Posner task was a TRS-80 Model I with 48K memory, an expansion interface, a single disk drive, and was previously adapted to present upper and lower case letters.

Computer Program for Reaction Time

A computer program was written in TRS-80 Level II BASIC to produce a version of the Posner task (Posner, Boies, Eichelman, & Taylor, 1969) similar to that described in Jackson (1980) and Jackson & McClelland (1979). The computer presented either two Perceptually Identical (PI) capital letters, a capital letter and the Name-Identical (NI) miniscule letter, or a capital letter and a Name-Different (ND) miniscule letter. If the two letters had the same name, the student was requested to press the "S" key, and for the

third condition, the "D" key. The computer program used the "1" key (if right handed) or the "5" key (if left handed) to originate a trial, so that the pacing of trials was controlled by the student. The student used the index and the middle fingers of his/her preferred hand to press the "S" or "D" key. The letters A, B, D, E, and R were used. The student sat approximately 18" (450 mm.) from the screen. The letters were 6.4 mm. high and had two spaces between them so the entire display was 12 mm. wide. Thus the display subtended a horizontal visual angle of 1.5 degrees and a vertical visual angle of .8 degrees.

The computer program started with an instruction section in which printout on the TRS-80 CRT briefly described the nature of the reaction time task. Then, the program requested specification of the student's preferred hand and set up the trial start procedure according to the hand indicated. Then, the program called for several more responses to help a student use the S and D keys appropriately.

The student then went through 20 practice trials of the Posner task. At the end, reaction time results and accuracy scores for each type of letter combination were printed out. If the student had any difficulty understanding the task, the assistant running the program reset the program to go through the practice trials again. If the practice trials appeared satisfactory, the 100 trial test was started.

On each of 100 trials, the microcomputer presented a "Press 1 to start" message (if the student was right-handed, or 5 if left-handed)

to indicate that the student could initiate a trial. When the identified key was pressed, one of the three letter combinations described above was presented. The trial was completed when either the "S" or "D" key was pressed. Timing of the reaction was accomplished by exiting a loop that started when the letter pair was presented (Perera, 1979). Each cycle of the loop took approximately 13 msec.

After the first 20 test trials had been presented, the microcomputer compared the percentage correct with the criterion of 80% (Jackson, 1980) and provided feedback of "Try faster," "O.K.," or "Try slower" depending on whether the percentage correct was above 82%, between 78 and 82% or below 78% respectively. This was done to control accuracy in terms of Wicklegren's (1979) demonstration of speed-accuracy tradeoffs so that the measured RT would be an unbiased measure of response speed. The basis for the feedback was computed for each trial for all presentations, unlike Jackson (1980) who only recalculated the feedback after blocks of 18 trials.

At the end of the 100 trials, the microcomputer printed the reaction time and the percentage correct for each type of letter combination and for the series of trials as a whole. Since each trial was programmed randomly, few students received a series of trials identical to any other series. The program took 12-20 minutes to complete.

Listening and Reading Comprehension

The listening comprehension and reading comprehension tests were

prepared by taking four pairs of paragraphs from the McCall-Crabbs (1979) booklet. Both paragraphs in each pair were about similar topics, and had similar lengths. The shorter of each of the pairs of paragraphs was used for listening comprehension. The passages for the listening comprehension test were read aloud by the teacher of the class. The reading comprehension test was administered by having each student read a paragraph silently within a time limit determined by the time taken to read the corresponding paragraph aloud. The time limit for each reading paragraph was calculated as the time which it would have taken for an instructor to read that paragraph aloud. After each paragraph, the student was given two minutes to answer the 8 questions from the McCall Crabbs booklet on a computer answer sheet. Students were not allowed to reread the paragraphs.

Procedure

Using a microcomputer, each subject participated in a memory speed task which obtained the access speed and the percentage of correct responses for each of three presentations of two letters. Each subject was administered a listening comprehension test and a reading comprehension test using passages taken from McCall & Crabbs (1979).

In addition, each student was administered the Diagnostic Reading Test or DRT (Committee on Diagnostic Reading Tests, 1966), a widely used measure of reading rate and comprehension that has generally been found to be appropriate to describe reading levels at Montclair State by faculty of the Reading Center. The DRT has

separate scores for rate, comprehension of narrative materials, comprehension of text-like materials, and reading vocabulary. In addition, a total score from the narrative, text, and vocabulary parts produced grade equivalents.

Results

Listening and Reading Comprehension

The listening and reading comprehension tests were quite closely related, showing a correlation of .847 (df=44, $p < .0001$). This correlation is at the upper end of correlations found between reading and listening comprehension, which generally range between .60 and .80 for older students (Stanovich, 1982). The number of students who took each test was considerably smaller than the total number of students in the study, since there was not time to assure that students who were absent when a group test was given were given makeups. In addition, 3 of the original 121 students dropped out of the course. Such a high correlation suggests little opportunity for locating differences between listening and reading. Even so, there was a clear pattern of higher correlations of the reading comprehension score with SAT and other measures of reading comprehension from the DRT. while there were lower correlations of the listening comprehension score with same measures of reading comprehension. These results are shown in Table 1. The mean Listening Comprehension score was 22.82 (out of 32) which was significantly higher than the mean Reading Comprehension score of 22.06 (t (70) = 2.19, $p < .05$).

Insert Table 1 here

The basic question concerns the extent to which reaction times

can supplement listening comprehension as predictors of reading comprehension. To investigate this question, a stepwise multiple regression procedure, PROC STEPWISE (SAS, 1979), was used. In this analysis, listening comprehension was forced to be the first predictor of reading comprehension and any of the three reaction times were allowed to enter when they made a significant additional contribution to prediction of reading comprehension. The second step included (F (1, 43) = 2.98, $p < .1$) the PI RT. In the third step, the NI RT (both reaction times with "same") was entered (F (1,42) = 10.68, $p < .003$) but the ND RT was not significant at the .15 level.

The R-square for the single predictor of listening comprehension was .7215 (F (1,44) = 114.01, $p < .0001$), which was slightly higher than the R-square for all the subjects who had completed both the listening and reading comprehension tests. The addition of the two "same" RTs increased the R-square to .7924. This use of the two reaction times thus accounted for 25.4 % of the residual error variance. This finding replicates Jackson's (1981) demonstration that reaction times which reflect retrieval processes could account for variance in reading comprehension which is not predicted by listening comprehension alone.

In this analysis, the NI RT served as a suppressor variable (Conger, 1974). To investigate the manner in which the suppressor acted, two new variables, Listening Comprehension with the NI RT partialled out (LC.NI) and PI RT with NI RT partialled out (PI.NI) were created. These were added to the previous set of predictors and PROC STEPWISE was run again. In this analysis, two significant

predictors, Listening Comprehension (F (1, 43) = 147.41, $p < .0001$) and PI.NI (F (1,43) = 14.54, $p < .0004$) were selected to produce a multiple R-squared of .7919 which is only slightly below the maximum possible R-square when all the variables were entered. This shows that all the suppressor effect was completely included in the role of the NI RT on the PI RT. The PI.NI predictor is given (approximately) by the formula:

$$VI.NI = VI(RT) - 0.5* NI(RT) \quad (1)$$

In light of Jackson's argument that it is specifically the NI RT, this suppressor function is of of particular interest. The regression coefficients for Listening Comprehension as a single predictor and with the composite RT variable were .816 and .814, respectively. The regression coefficients for the reaction time to the two capital letters (30.02) and to capital and small letters (-14.39) form a comparison in which, again, half of the NI RT is nearly twice as long as the PI RT. Thus, only when the NI RT is substantially longer than the PI RT is there a prediction of poorer Reading Comprehension than Listening Comprehension. This supports Jackson's (1980) emphasis on NI RT (as a measure of name retrieval) as the effective predictor of poorer reading than listening comprehension and shows that it is not simply motor speed, measured equally by the two RTs that serves as the predictor.

Two further approaches to finding the difference between the reading comprehension and listening comprehension scores were used. The first was the simple difference between the scores for the listening and reading comprehension tests. The second was a similar

difference between the standarized (z) scores for reading comprehension and listening comprehension scores. The difference in reading and listening comprehension was predicted with an R-Square of .225, thus indicating that 22.5% of the residual variance was predicted by the same two reaction time measures. When the difference between the standardized scores was used, the two reaction times predicted 25.4 % of the variance. Thus, regardless of how the prediction is made, these reaction times, with the reaction time to the capital letters given about twice the weight of the reaction time to identical capital and small letters, seems to account for differences in reading and listening comprehension.

Speed/Accuracy Tradeoff

Jackson's version of the Posner task included an attempt to control for the trade-off between speed and accuracy that is found in many intra-individual studies (Wickelgren, 1979). Figures 1-3 show the relation between speed and accuracy found for the subjects in the current study.

Insert Figs. 1-3 here

Fig. 1 shows very little evidence of an inter-individual speed-accuracy trade-off, probably because the proportions are overwhelmingly near 100%, with a few cases showing one error and one case each representing two and three errors, respectively. Fig. 2, where the accuracy goes below 60%, and Fig. 3, even though the bulk

of cases show 1 or 2 errors, show substantial evidence of inter-individual speed accuracy trade-offs. In both Figs. 2 and 3, there are a few cases with low accuracy and relatively short reaction times, while there are some reaction times which are quite long and which show high accuracy.

In order to investigate the importance of the speed-accuracy tradeoff in this task, a STEPWISE multiple regression in which the proportion correct for each of the reaction time measures as well as the preceding predictors of listening comprehension and reaction time were used as predictors of reading comprehension. None of the proportion correct predictors added any significant variance to the regression equation. Thus, it does not appear that accuracy, beyond what is demanded by the task, is an important predictor of reading comprehension, nor does it seem to assist in aiding the prediction provided by listening comprehension and reaction time.

Discussion

This study has succeeded in its main aim, that of demonstrating that a retrieval speed measure would improve prediction of a reading comprehension task. Thus Jackson's (1980) assertion that retrieval speed produces improved prediction of reading comprheension is supported. This study did not find that the speed-accuracy trade-off was important in an individual difference sense. Nor was there any simple relation from this speed/accuuracy comparison to reading comprehension.

The present study shows, too, that the level of reaction times found for this study could influence the reading process. The largest difference in the composite reaction time (eq. 1) which was observed was approximately 15 msec. If a student reads 200 words per minute (approximately 1000 letters per minute or 16.7 letters per second), this reaction time would add 250 msec. to the time required to read one second's letters. This increase in reading time of about 25 percent could substantially hamper reading rate.

It is possible that the finding from the speed measures on the Posner task does not reflect retrieval speed as we suppose, but instead shows its effect because it measures the speed or "automaticity" of decoding. While we did not measure decoding speeds, it is unlikely that these students have decoding problems since it has been the consistent experience of faculty and graduate assistants that these students rarely, if ever, show decoding problems. Indeed, it has been found on a similar population by Dutka & Haupt (Note 1) that differences in comprehension subskills are best explained by

frequency choosing correct reading comprehension subskills (meatacomprehension choices). This suggests that standard reading tests (e.g., the DRT) and even use of comprehension subskills (metacomprehension utilization) are not effective predictors of college reading comprehension in these students.

The explanation for increased prediction has focused on retrieval speed. Perfetti's "bottleneck" hypothesis might be considered an alternative explanation in that the apparent retrieval speed differences might only be derivative of space limitations in primary memory. There are two reasons to suggest that the bottleneck hypothesis does not account for the results of this study. First, decoding differences are unlikely or minimal among these adult readers. Second, the Posner task would seem only to require 1 or 2 chunks of primary memory even if, as Paap & Ogden (1981) have shown, letter identification does indeed demand primary memory capacity. The Posner task also seems to take little enough time (RTs range from .5 to .7 seconds) so that it cannot index difficulties resulting from an insufficiency of primary memory (which has a half-decay time of at least 3 seconds).

Another possible interpretation concerns the extent to which this measure of retrieval speed is simply another aspect of the rapid processing associated with being "high verbal," e.g., Hunt (1978) although Kirby and Das (1977) found speed to be separate from verbal and spatial ability. There are several problems with this interpretation. First, Hunt used the SAT, a reading comprehension test, and thus confounded his measures of processing speed with

reading. In addition, the best retrieval speed measure is independent of DRT total score (r (49) = .139 p < .4) and independent (r (26) = .126, p < .6) of SAT as well.

Thus, for now, it appears that an interpretation that makes name retrieval speed at least one of the factors that contributes to adult reading comprehension is on firm ground.

Footnotes

(1) The authors would like to thank Susan Campbell for her assistance in running subjects, gathering data, and preparing data for analysis. In addition, Steven Boardman, Bonnie Tramonte, and Susan Rogers were of great assistance in gathering data from their classes and scheduling students.

(2) Support for the performance of this experiment and preparation of data for analysis was provided through funds for Separately Budgeted Research, Montclair State College, New Jersey State Department of Higher Education.

Reference Note

1. Dutka, J. T., & Haupt, E. J. Metacomprehension and comprehension: A study of specific validity. Paper presented at American Educational Research Association, Montreal, Canada, April, 1983.

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Table 1

Correlations of Reading and Listening Comprehension Scores with Several other Reading Scores

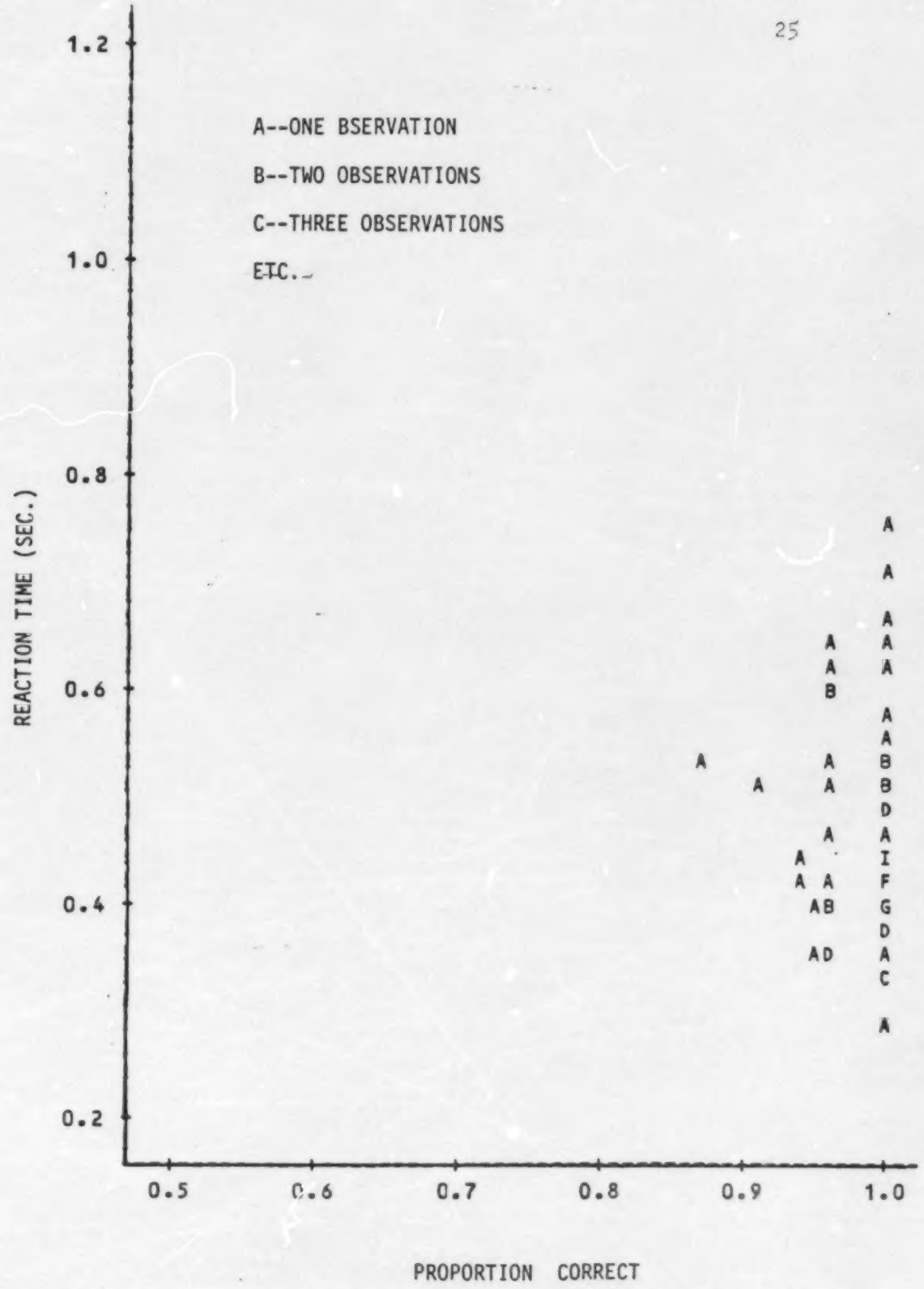
Reading Comprehension Score	Reading Comprehension	Listening Comprehension
SAT Verbal	.709	.696
DRT Narrative	.484	.471
DRT Text	.729	.597
DRT Vocabulary	.674	.587
DRT Rate	.509	.403

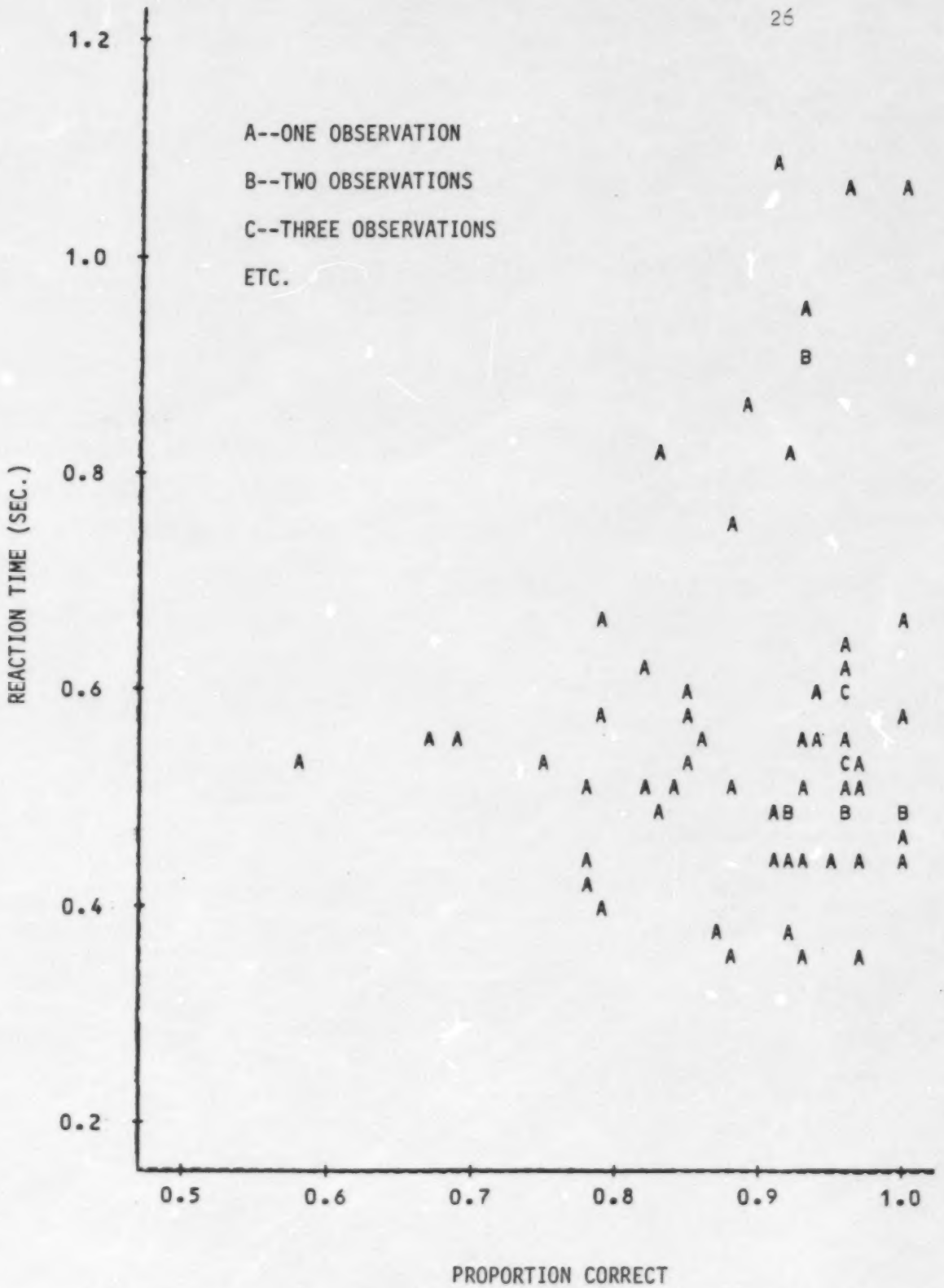
FIGURE CAPTIONS

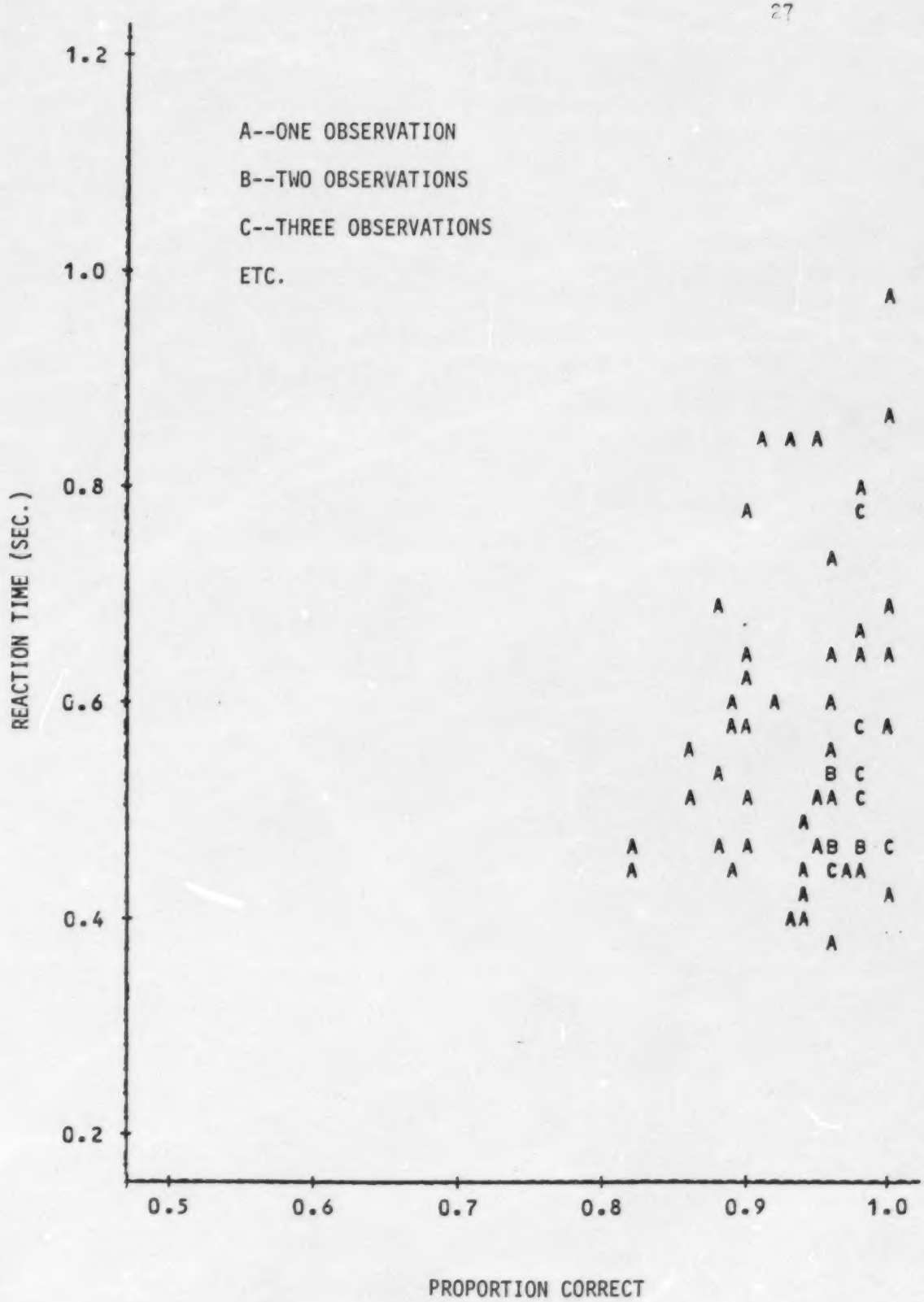
Fig. 1. Reaction time for each subject as a function of percentage correct in PI displays.

Fig. 2. Reaction time for each subject as a function of percentage correct in NI displays.

Fig. 3. Reaction time for each subject as a function of percentage correct in ND displays.


A--ONE BSERVATION
B--TWO OBSERVATIONS
C--THREE OBSERVATIONS
ETC.
REACTION TIME (SEC.)
1.2
1.0
0.8
0.6
0.4
0.2
0.5
0.6
0.7
0.8
0.9
1.0
PROPORTION CORRECT


A--ONE OBSERVATION
B--TWO OBSERVATIONS
C--THREE OBSERVATIONS
ETC.
REACTION TIME (SEC.)
1.2
1.0
0.8
0.6
0.4
0.2
0.5
0.6
0.7
0.8
0.9
1.0
PROPORTION CORRECT


A--ONE OBSERVATION
B--TWO OBSERVATIONS
C--THREE OBSERVATIONS
ETC.
REACTION TIME (SEC.)
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0.2
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PROPORTION CORRECT